A METHOD AND APPARATUS FOR LOCATING AN EDGE DISPOSED AT THE JUNCTION BETWEEN TWO SUBSTANTIALLY PLANE SURFACES

The invention relates to a method and to apparatus for locating, in a reference plane, an edge disposed at

5   the junction between two substantially plane surfaces, and in particular to a method and to apparatus for locating a platform edge coping relative to a rail vehicle. The invention also relates to a guiding method using such a location method and in particular a method

10   of guiding a moving step on a rail vehicle relative to a platform edge coping.

BACKGROUND OF THE INVENTION

In the field of rail vehicles, it is known that moving steps can be used to make it easier for passengers

15   to board from a platform and to alight onto a platform, it being possible for such steps to have strokes controlled automatically by means of telemeters in order to optimize the final resulting gap between the step and the platform. Such apparatus is, for example, disclosed

20   in Document US 6 341 563 which describes a system for controlling a moving step relative to a platform. In that system, two telemeters are used to measure the distance between the moving step and the platform by means of a triangulation method, each telemeter being

25   made up of an ultrasound transmitter and detector. Unfortunately, locating the platform by using a location method suffers from the drawback of not enabling the edge coping of the platform to be located very accurately, and of further requiring the two ultrasonic telemeters to be

30   far enough away from the platform and far enough apart to give a result that can be used. As shown in Figure 1, the triangulation method makes it possible, by means of two ultrasonic telemeters T carried by the vehicle to locate a point P' corresponding to the point of

35   intersection between two circles representing distance to the obstacle as measured by each of the telemeters. As shown in Figure 1, the point P' obtained by the

triangulation method gives an acceptable approximation of the point P corresponding to the edge coping of the platform when the two ultrasonic telemeters are far enough apart. However, when the two telemeters T are

5 close together, as shown in Figure 2, the two circles representing distance to the obstacle as measured by the telemeters cannot intersect, and the triangulation method no longer makes it possible to measure the position of the point P'.

10 OBJECTS AND SUMMARY OF THE INVENTION

Thus, an object of the present invention is to provide a method and apparatus that make it possible to locate the edge coping of a platform relative to a rail vehicle with good accuracy. Another object of the

15 invention is to provide a location method that can operate with telemeters disposed close together.

To this end, the invention provides a method of locating, in a reference plane, an edge that is disposed at the junction between two surfaces that are

20 substantially plane, said reference plane being substantially perpendicular to the surfaces, said method comprising the following stages:

a) transmitting waves from at least one transmitter disposed in the reference plane, said transmitter having

25 a transmit solid angle that enables at least some transmitted waves to reach both of said surfaces on either side of said edge;

b) receiving the echoes of the waves transmitted by the transmitter in at least two receivers which are

30 disposed in the reference plane such that one of the receivers essentially receives the waves reflected by one of the surfaces while the other receiver essentially receives the signals reflected by the other surface, the positions of the receivers and of the transmitter in the

35 reference plane being known by construction;

c) analyzing the energy of the signal received by each receiver to determine the value of the angle of

inclination between the main transmit axis of the transmitter and the normal to the surface that has reflected the waves picked up by said receiver;

d) computing the position in the reference plane of the point of impact of the waves on each surface by measuring the travel time of the signal transmitted by the transmitter and received by each receiver; and

e) locating said edge in the reference plane by computing the point corresponding to the intersection of the straight lines passing through the respective points of impact on the two surfaces and forming respective angles with the main transmit axis of the transmitter that correspond to the angles of inclination computed during stage c) for each of said surfaces.

In particular implementations, the location method of the invention may have one or more of the following characteristics taken in isolation or in any technically feasible combination:

during stage c), the angle of inclination between the main transmit axis of the transmitter and the normal to the surface that has reflected the waves picked up by the receiver is determined by computing the gradient of the curve representing the normalized energy of the signal received by said receiver over time, said gradient being a function of the angle of inclination and satisfying a relationship predetermined by experimental measurements;

the transmitter and the receivers are ultrasonic;

the edge is the edge coping of a boarding platform, and the reference plane is carried by a rail vehicle having a moving step; and

the waves are transmitted from a single transmitter disposed mid-way between two receivers while being in alignment with them.

The invention also provides apparatus for locating, in a reference plane, an edge disposed at the junction between two substantially plane surfaces by means of a

method as described above, said apparatus comprising at
least one transmitter and at least two receivers disposed
in the reference plane, said transmitter having a
transmit solid angle making it possible for at least some
5   waves transmitted by said transmitter to reach both of
the surfaces on either side of said edge, the receivers
being disposed in the reference plane such that one of
the receivers essentially receives the waves reflected by
one of the surfaces while the other receiver essentially
10   receives the signals reflected by the other surface, the
positions of said transmitter and of said receivers in
the reference plane being known by construction.

In particular embodiments, the location apparatus of
the invention may have one or more of the following
15   characteristics taken in isolation or in any technically
feasible combination:

the edge is the edge coping of a boarding platform,
and the reference plane is carried by a rail vehicle
having a moving step;

20   the moving step supports a single transmitter and
two receivers disposed in a plane perpendicular to the
longitudinal axis of the rail vehicle, said receivers
being disposed on either side of the transmitter while
being in alignment on a straight line inclined relative
25   to the vertical;

the straight line on which the receivers and the
transmitter are in alignment is inclined by about 30°
relative to the vertical; and

the transmitter and the receivers are ultrasonic
30   transducers.

The invention also provides a method of guiding a
moving element relative to an edge disposed at the
junction between two substantially plane surfaces, said
method including a location stage during which the edge
35   is located by means of the above-described method.

According to another characteristic of the guiding
method of the invention, the location stage is performed

iteratively while the moving element is being guided relative to the edge.

According to yet another characteristic of the guiding method of the invention, the moving element is a
5 step on a rail vehicle and the edge is the edge coping of a platform, the step supporting a single transmitter and two receivers disposed in a plane perpendicular to the longitudinal axis of the rail vehicle, the receivers being disposed on either side of the transmitter while
10 being in alignment on a straight line inclined relative to the vertical.

According to yet another characteristic of the invention, when the location method does not make it possible to locate the platform edge coping, the travel
15 times of the waves transmitted by the transmitter and received by the receivers after being reflected off the platform are compared to determine whether the step is situated above or below the platform edge coping.

BRIEF DESCRIPTION OF THE DRAWINGS
20 The objects, aspects, and advantages of the present invention will be better understood on reading the following description of a particular embodiment of the invention given by way of non-limiting example and with reference to the accompanying drawings, in which:
25 Figures 1 and 2 are views diagrammatically showing the principle of location by triangulation in the above-described prior art;

Figure 3 is a view in section on a vertical plane of a retractable step of a rail vehicle in the folded-away
30 position, the step being equipped with locating and guiding apparatus of the invention for locating the platform edge coping and for guiding the step relative thereto;

Figure 4 is a view similar to Figure 3 when the
35 retractable step is in the deployed position;

Figure 5 is a graph showing the general appearance over time of the voltage of the signal delivered by one

of the receiver transducers of the location apparatus of
the invention when it receives the echo of a wave
transmitted by a transmitter;

Figure 6 is a graph showing the general appearance
over time of the energy of the signal picked up by one of
the receiver transducers of the location apparatus of the
invention when it receives the echo of a wave transmitted
by a transmitter;

Figure 7 is a diagrammatic fragmentary view showing
location apparatus of the invention facing two reflection
walls that are inclined differently;

Figure 8 is a graph showing the energy of the signal
picked up by the receiver of the location apparatus of
Figure 7 as a function of the inclination of the
reflection wall; and

Figure 9 is a diagram geometrically showing how the
position of the platform edge coping is determined during
the last stage of the location method of the invention.

MORE DETAILED DESCRIPTION

To make the drawings easier to understand, only
those elements which are required to understand the
invention are shown. Like elements bear the same
references from one figure to another.

Figures 3 and 4 show the bottom portion of a rail
vehicle 3 stopped in the vicinity of a platform 2, the
vehicle having a retractable step 1 provided with
location apparatus of the invention. In the description
below, only the mechanism supporting one side of the
retractable step 1 is described with reference to Figures
3 and 4, the step 1 having a similar mechanism on the
other side.

As shown in Figure 3, the step 1 is formed by a
horizontal plate having a front edge to which location
apparatus is attached that is constituted by an
instrument-carrying wall 10. The instrument-carrying
wall 10 extends under the step 1 at a angle of about 30°
to the vertical, and supports an ultrasonic remote

measurement system made up of two receivers R1 and R2 and
of one transmitter E. For example, the transmitter E and
the receivers R1 and R2 may be Murata waterproof
ultrasonic transducers, respectively of the MA40E7S type
5   and of the MA40E7R type. Such ultrasonic transmitter or
receiver transducers offer the advantage of having
respective transmit and receive solid angles of
about 60°.

The receivers R1 and R2 are disposed respectively at
10   the top edge and at the bottom edge of the instrument-
carrying wall 10, and the transmitter is disposed midway
between the two receivers R1 and R2. The back faces of
the receivers R1 and R2 and of the transmitter E are
disposed against the instrument-carrying wall 10 so that
15   the axis of the transmit cone of the transmitter E and
the axis of the receive cone of each receiver R1 and R2
are inclined relative to the horizontal by 30° downwards.
The transmitter E and the receivers R1 and R2 are
connected to a computer (not shown) for processing the
20   measured signals.

The step 1 is supported at each of its side ends by
two links 4 in the form of goosenecks, the heads of the
two links 4 being fixed in the vicinities respectively of
the front edge and of the back edge of the step 1 by
25   means of respective hinges 4a. Each link 4 also has a
foot connected via a hinge 4b to a slide 7 mounted to
move in a horizontal slideway 17 fixed under the vehicle
3 via two fixing brackets 11. The link 4 that is
connected to the back portion of the step 1 is secured to
30   a lever 5 extending perpendicularly to the foot of the
link, the end of said lever 5 being fixed to the head of
an electric actuator 6 whose foot is fixed to the
slide 7. As shown in Figure 4, the rod of the electric
actuator 6 turns the back link 4, thereby causing the
35   step 1 to be moved vertically.

Horizontal movement of the step 1 can be controlled
independently of the movement of the links 4, by moving

the slide 7 in the horizontal slideway 17, the back end
of the slide 7 being connected via an angle bar having a
rack provided with a worm screw 8 driven in translation
by a wheel connected to an electric motor 9 carried by
5   the slideway 17.

The method of locating the step 1 relative to the
platform 2 is described below.

As shown in Figures 3 and 4, one or more ultrasound
waves are transmitted towards the platform 2 from the
10   transmitter E on the moving step 1 when the rail vehicle
is stopped in a passenger station. Since the transmit
solid angle of the transmitter is about 60°, as shown in
dashed lines in the figures, the waves transmitted by the
transmitter E generally reach the edge coping P of the
15   platform 2 and are reflected both by the top face 2a of
the platform 2 and by its side face 2b. After they
reflect off the platform 2, the echoes of said waves are
measured at the receivers R1 and R2, each of said
receivers having a receive solid angle of about 60° shown
20   in dashed lines in the figures.

An example of the appearance over time of the signal
delivered by the receivers R1 or R2 is shown in Figure 5.
As shown in Figure 5, a wave peak resulting in a voltage
peak is measured by the receivers R1 or R2. By means of
25   a processing computer, the signals measured by the
receivers R1 and R2 are integrated in real time, and then
normalized relative to the total energy received by the
corresponding receiver, to obtain a curve of the energy
of the measured signal lying in the range 0% to 100% as
30   shown in Figure 6.

In a following stage of the method, the processing
computer determines the gradient of the curve of the
normalized energy measured at each of the detectors R1
and R2 by computing the gradient of the straight line
35   passing, for example, through the points e1 and e2 for
which the energy is respectively equal to 10% of the
total measured energy and 90% of said total measured

energy. On the basis of the value of the gradient of the curve of the normalized energy corresponding to the receivers R1 and R2, the computer deduces respectively the angles α1 and α2 formed by the normals to the wave

5 reflection surfaces relative to the axis of the transmit cone of the transmitter E. The value of each of the angles α1 and α2 is computed by means of an equation giving the value of the angle α as a function of the gradient of the curve of the normalized energy, said

10 equation being obtained previously by measuring experimentally the various gradients of the curve of the normalized energy for each of the receivers R1 and R2 when the instrument-carrying wall 10 is placed in front of a reflection surface inclined at different

15 inclinations.

The Applicant has observed that the normalized energy curve is substantially constant for any given receiver, and that the gradient of the energy curve is a function of the angle formed by the reflection surface

20 relative to the transmitter. By way of example, with reference to Figure 7, when a wave transmitted by the transmitter E is reflected by a surface s1 perpendicular to the axis of the transmit cone, the curve of the normalized energy measured by means of the detector R2 is

25 similar to the curve c1 shown in Figure 8, and when the wave transmitted by the transmitter E is reflected by a surface s2 forming an angle α with the surface s1, the curve of the normalized energy measured by means of the detector R1 is similar to the curve c2.

30 In another stage of the method, the computer determines the co-ordinates of the main point of impact of the waves on the surface of the platform 2 that has reflected the waves. As shown in Figure 9, the co-ordinates of said point of impact are determined by

35 estimating that the point of impact that has reflected the largest proportion of the transmitted waves lies on the mid-perpendicular of the segment formed by the

transmitter E and by the corresponding receiver R1 or R2, i.e., with reference to the figure, point S for the receiver R1 and point V for receiver R2. The co-ordinates of the point S can be determined by estimating

5   that the travel time taken by the wave transmitted by the transmitter E, and then reflected at the point S, finally to be measured by receiver R1 corresponds substantially to the travel time measured for e3=50% on the curve of the normalized energy measured by the detector R1. This

10 travel time corresponds to a distance d1 obtained by dividing the travel time by the speed of propagation of the ultrasound wave. Similarly, the co-ordinates of the point V are determined by estimating that the travel time taken by the wave transmitted by the transmitter E, and

15 then reflected at the point V, finally to be measured by the receiver R2 corresponds substantially to the travel time measured for e3=50% on the curve of the normalized energy measured by the detector R2. This travel time corresponds to a distance d2 obtained by dividing the

20 travel time by the speed of propagation of the ultrasound wave.

Since the distance $\underline{f}$ between the transmitter E and the receivers R1 and R2 is known by construction, the co-ordinates of the points S and V in the reference frame

25 xR1y may be written by approximation:

$$S = \begin{pmatrix} xs \approx d1/2 \\ ys = f/2 \end{pmatrix}$$

30 $$V = \begin{pmatrix} xv \approx d2/2 \\ yv = 3f/2 \end{pmatrix}$$

On the basis of knowledge of the co-ordinates of the points S and V, the computer then determines merely by geometrical construction the co-ordinates of the point N

35 corresponding to the intersection where the straight line D1 passing through S of gradient α1 intersects the straight line D2 passing through V of gradient α2, where α1 and α2 are the angles determined during the preceding

stage of the method. The co-ordinates of the point N obtained in this way give a good estimation of the position of the edge coping P of the platform 2.

Such a location method offers the advantage of enabling a platform edge coping to be located accurately with receivers and transmitters disposed close together. The location apparatus of the invention also offers the advantage of requiring only one transmitter and two receivers in order to operate.

The invention also relates to a method of guiding the step 1, which method incorporates the above-described method of locating the platform edge coping P so as to bring the step 1 into an optimized position relative to the platform edge coping P.

Such a method of guiding the step 1 advantageously uses the above-described location method iteratively so as to know the position of the step 1 relative to the platform edge coping P at any time, and acts accordingly on the electric actuator 6 and on the motor 9 respectively controlling the height and the lateral position of the step 1 so as to bring said step into the desired position.

In a preferred implementation, the guiding method also takes account of the cases when the location method does not make it possible to obtain the co-ordinates of the point N because the zone swept by the transmitter E does not reach the edge coping P of the platform 2. Such a case can occur when the platform 2 is very high and when the step 1 is in a position that is too low for the waves transmitted by the transmitter E to be reflected by the top surface 2a of the platform 2. Such a case may also occur when the platform 2 is very low and when the step 1 is in a position that is too high for the waves transmitted by the transmitter E to be reflected by the side face 2b of the platform 2.

These cases are detected by the guiding method merely by analyzing the angles formed between the

straight lines D1 and D2 computed by the location method: said angles should normally always remain close to 90°. Thus, when the straight lines D1 and D2 from the location method form an angle between them that is smaller than a
5 given threshold, e.g. 60°, the guiding method compares the travel times of the wave transmitted by the transmitter E and picked up by the receivers R1 and R2 to detect whether the waves are reflected by the top surface 2a or by the side surface 2b of the platform. When the
10 travel time of the wave picked up by the receiver R1 is shorter than the travel time of the wave picked up by the receiver R2, that indicates that the instrument-carrying wall 10 is facing the side wall 2b of the platform 2, and the guiding method controls the electric actuator 6 so as
15 to raise the step 1 until the instrument-carrying wall 10 can detect the edge coping of the platform 2. Conversely, when the travel time of the wave picked up by the receiver R1 is longer than the travel time of the wave picked up by the receiver R2, that indicates that
20 the instrument-carrying wall 10 is above the top wall 2a of the platform 2 and the guide method controls the electric actuator 6 so as to lower the step 1 until the instrument-carrying wall 10 can detect the edge coping of the platform 2.

25   Naturally, the invention is in no way limited to the implementation described and shown, which is given merely by way of example. Modifications remain possible, in particular concerning the make up of the various elements, or the use of equivalent substitute techniques,
30 without going beyond the scope of protection of the invention.

    Thus, in the above-described embodiment, the angle of inclination of the instrument-carrying wall relative to the vertical is chosen to be equal to 30°. However,
35 in variant embodiments, the angle may be modified and preferably lie in the range 20° to 70°.